MWI 8715.1
REVISION A
EFFECTIVE DATE: May 9, 2001
EXPIRATION DATE: May 9, 2006

MARSHALL WORK INSTRUCTION

QS01

ELECTRICAL SAFETY

DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Baseline		12/20/99	
Revision	A	5/9/01	Renumbered document in accordance with MPG 1410.2; rewrote P.1; changed P.2 to read "…applies to all MSFC employees and contractor personnel at MSFC that are exposed to unguarded energized electrical components and equipment during maintenance, service or troubleshooting activities…"; added MWI 3410.1, MWI 8715.15, MIL-HDBK-454, NFPA 70, ANSI ISA-S82.01-1988, 29 CFR 1910.147, and 29 CFR 1910.303 to section 3; "deleted "c" in section 3, applicable documents, and added 3.8 through 3.10; added 4.1, 4.2, and 4.3; added definition for authorized employee, buddy system, CPR, CERTRAK, Energized, Exposed, and Guarded; updated definition for qualified person; updated paragraph 6.1.2 to read "Verify if personal protection equipment is required for the job. If required ensure PPE meets…"; changed paragraph 6.1.3 to read "If not, a lockout/tagout procedure and authorized employee shall be required. (Reference…"; added 6.1.4.1-6.1.8; added 6.1.10, 6.1.11, 6.2.1-6.2.2.2, 6.2.5 and 6.2.5.1, 6.2.7-6.3.1.3; added "tag it out (reference MWI 8715.3) and" to paragraph 6.3.2; changed paragraph 6.3.8 to read "Extension cord length in the office area shall not exceed 15 feet. Extension cord length…"; added paragraph 6.3.15; added 6.4.2.1, 6.4.4.1, and 6.4.5.1; added paragraph 6.4.2.3; deleted paragraph 6.d.(6); changed paragraph 6.4.6 to read "…etc.). Reference MWI 8715.11, "Fire Safety Program," section 6.6, "Portable Appliances," for exact requirements"; deleted "NOTE 1" and "NOTE 2" after paragraph 6.4.6; changed 6.6.4 to read "Safe working access and clearance…shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of the equipment. Clearance distances shall comply with 29 CFR 1910.303 (g) Table S-1"; added 6.4.15 and 6.4.16; added 6.5.2.2-6.5.2.4; added paragraph 6.7.3; added 6.8.3; changed paragraph 9.1 to read "All employees that may be exposed to energized electrical components shall be trained in and familiar with the safety-related work practices required by 29 CFR 1910.331 through 335 that pertain to their respective job assignments. This training may be performed during a Safety Meeting and maintained by the Supervisor"; added 9.2 and 9.3 to section 9; changed paragraph 10.1 to read "Supervisors shall ensure employees who are exposed to energized electrical equipment and face a risk of electric shock that is not reduced to a safe level or are exposed…task. At a minimum will ensure the employee is trained and familiar with:" added 10.1.1 through 10.1.3;

			revised paragraph 10.2 to read "…components are required to be trained…"; added 10.3-10.3.11; and added paragraph 10.7.

1. PURPOSE

The requirements and guidelines in this Directive apply to the safety precautions to be taken by employees when exposed to energized conductors and electrical circuit parts at Marshall Space Flight Center (MSFC). It also addresses the safety requirements for electrical equipment and associated components when being used at MSFC.

2. APPLICABILITY

This Directive applies to all MSFC employees and contractor personnel at MSFC that are exposed to unguarded energized electrical components and equipment during maintenance, service, or troubleshooting activities. It applies to all ground-based activities at MSFC and all MSFC facilities, systems, equipment, and property. High-voltage transmission lines are maintained and serviced by the Redstone Arsenal utility organization and are excluded from this document.

3. APPLICABLE DOCUMENT

3.1 MWI 3410.1, “Personnel Certification Program”

3.2 MWI 8715.2, “Lockout/Tagout Program”

3.3 MWI 8715.3, “Hazard Warning Signs and Barricades”

3.4 MWI 8715.4, “Personal Protection Equipment (PPE)”

3.5 MWI 8715.11, “Fire Safety Program”

3.6 MWI 8715.15, “MSFC Safety Assessment Program”

3.7 NPG 8715.3, “NASA Safety Manual”

3.8 MIL-HDBK-454, “Standard General Requirements for Electronic Equipment”

3.9 NFPA 70, National Electric Code (NEC), Article 305, “Temporary Wiring”

3.10 29 CFR 1910.147, “The Control of Hazardous Energy (Lockout/Tagout)”

3.11 29 CFR 1910.303, “General Requirements”

3.12 29 CFR 1910.332, “Training”

3.13 29 CFR 1910.333-335, “Electrical Safety-Related Work Practices”

4. REFERENCES

4.1 MPG 3410.1, “Training”

4.2 NFPA 70, NEC, “National Electric Code”

4.3 NFPA 70E, “Electrical Safety Requirements for Employee Workplaces”

4.4 NASA Safety Training Course, NSTC 309, “Electrical Safety”

4.5 ANSI/ISA-S82.02.01-1999, “Safety Standards for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment – General Requirements”

4.6 29 CFR 1926.416 and 417, “Electrical Safety-Related Work Practices”

5. DEFINITIONS

5.1 Authorized Employee. Employees who lock out and tag out machines or equipment in order to perform servicing or maintenance on the machine or equipment and meet the training requirements in section 10.

5.2 Buddy System. While one person works on the equipment, another person trained to recognize the electrical hazards will be delegated to watch the movements of the other person to warn them if they get dangerously close to live conductors or perform unsafe acts and to assist them in the event of an accident.

5.3 Cardiopulmonary Resuscitation (CPR). A procedure designed to restore normal breathing after cardiac arrest that includes the clearance of air passages to the lungs and heart massage by the exertion of pressure on the chest.

5.4 CERTRAK. The Safety and Mission Assurance (S&MA) Office software data base system used for employee certification records.

5.5 Energized. Electrically connected to a source of potential difference.

5.6 Exposed. Capable of being inadvertently touched or approached at less than a safe distance, it is applied to parts that are not suitably guarded, isolated, or insulated.

5.7 Guarded. Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects.

5.8 Qualified Employee. Employees permitted to work on or near unguarded exposed electrical components and equipment during maintenance, service, and troubleshooting activities. The employee is also knowledgeable in the construction and operation of the equipment and meets the training requirements in section 10.

6. INSTRUCTIONS

All electrical wiring, appliances, fixtures, etc., shall be designed, installed, and maintained in accordance with NFPA 70E, NEC standards, and MIL-STD-454, “Standard General Requirement for Electronic Equipment.”

6.1 Before Working on Electrical Circuits or Equipment:

6.1.1 Remove metal jewelry, watches, rings, etc.

6.1.2 Verify if personal protection equipment (PPE) is required for the job per an operating procedure (OP) or job hazard analysis (JHA) in accordance with MWI 8715.15, “MSFC Safety Assessment Program,” or PPE Assessment in accordance with MWI 8715.4, “Personal Protective Equipment (PPE).” If required, ensure PPE meets the requirements of 29 CFR 1910.333(C)(2), “Work on Energized Equipment,” or 335(a), “Use of Protective Equipment.”

6.1.3 Verify that the energy source and/or plug is exclusively under the control of the qualified employee performing the service or maintenance. If not, a lockout/tagout procedure and authorized employee shall be required. (Reference MWI 8715.2, “Lockout/Tagout Program.”)

6.1.4 Verify the power is turned off to the equipment and unplug equipment before troubleshooting, servicing, performing maintenance, and checking or replacing fuses. For exceptions, reference section 6.2.

6.1.4.1 Equipment shall be deenergized prior to performing maintenance, service, and troubleshooting if there is a possibility that an employee may work on or near exposed energized parts. Energized parts that operate at less than 50 volts to ground need not be deenergized if there will be no increased exposure to electrical shock or other injuries resulting from direct or indirect electrical contact.
NOTE: If deenergizing the equipment introduces additional or increased hazards or is infeasible due to equipment design or operational limitations, reference section 6.2.

6.1.5 Verify adequate illumination is provided while working on the electrical equipment, equipment room, work bench, etc., in compliance with 19 CFR 1910.303 (g)(v), “Illumination.”

6.1.6 Verify sufficient access and working space is provided and maintained for all electrical equipment to permit ready and safety operation and maintenance. Clearance distances shall comply with 29 CFR 1910.303 (g)(i), “Working Clearances,” Table S-1, “Working Clearances.”

6.1.7 Verify your escape route from the equipment or system is not blocked.

6.1.8 Verify the reason a fuse was blown or a breaker was tripped. Correct the problem before replacing the fuse or resetting the breaker and energizing the circuit or system.

6.1.9 Safely discharge any capacitors in the equipment before working on the electrical circuits.

6.1.10 Verify equipment chassis or cabinets are grounded before beginning maintenance, service, or troubleshooting activities.

6.1.11 Do not defeat the purpose of a fuse or circuit breaker, and never install a fuse of a higher amperage rating than specifically listed for the circuit.

6.1.12 Do not work on electrical equipment in wet areas or when touching objects that may provide a hazardous earth-ground path.

6.1.13 Check the electrical rating of the equipment you use and ensure the equipment is within its rating for the intended use.

6.1.14 Do not place any containers of liquid on electrical equipment.

6.2 When working on or near exposed energized parts or electrical equipment:

6.2.1 Additional safety-related work practices shall be used to protect qualified employees who may be exposed to, or may come in contact with, energized circuit parts, operating at greater than 50 volts to ground, directly with any part of the body or indirectly through some other conductive means.

Example: The cover or panel is removed from energized electrical equipment for the qualified employee performing troubleshooting activities, taking measurements, or making adjustments.

6.2.1.1 Additional safety-related work practices shall be in accordance with 29 CFR 1910.333, “Selection and Use of Work Practices.”

6.2.2 Operations on energized equipment will be permitted **ONLY** in the following circumstances:

6.2.2.1 If fine adjustments on the machine or equipment must be made and can only be completed if it is energized.

6.2.2.2 During troubleshooting activities when energization is required to locate the source of the problem, and when checking to ensure the problem has been corrected.

6.2.3 Protective shields, protective barriers, or insulating materials shall be used to protect qualified employees from shock, burns, or other electrically related injuries while that employee is working near exposed energized parts which might be accidentally contacted or where dangerous electric heating or arcing might occur.

6.2.4 When normally enclosed live parts are exposed for maintenance or repair, they shall be guarded to protect qualified employees and other employees in the immediate area from contact with the live parts.

6.2.5 All exposed electrical terminals shall be guarded when a qualified employee leaves the immediate area when performing maintenance, service, or troubleshooting activities.

6.2.5.1 Guard all exposed electrical terminals by replacing panel covers, placing signs or tags on the equipment notifying other employees of the potential hazard, or placing barricades around the equipment.

6.2.6 Supervisors shall ensure that no person works alone with electricity in excess of 600 volts. The buddy system shall be used.

6.2.7 Supervisors shall ensure the buddy system is used for all jobs/tasks deemed as hazardous work in a procedure or a hazard analysis.

6.3 Hazardous Electrical Work:

6.3.1 All electrical work deemed hazardous by a hazardous analysis (reference MWI 8715.15, “MSFC Safety Assessment Program”) shall only be performed by a qualified employee and will meet the following requirements:

6.3.1.1 A qualified employee engaged in this electrical work shall be instructed in accident prevention and fully informed of the hazards involved.

6.3.1.2 A qualified employee shall be trained in first-aid procedures that include CPR.

6.3.1.3 All electrical work deemed as hazardous work by a hazardous analysis shall be performed using the buddy system.

6.4 Extension Cords:

6.4.1 Inspect cabling for defects such as frayed wiring, loose connections, cracked insulation, and loose strain reliefs.

6.4.2 When a defective cord or plug is discovered:

6.4.2.1 If the defective extension cord is a factory-assembled cord, remove it from service and discard. Cut the plug off or any means necessary to ensure the extension cord will not be used by another employee.

6.4.2.2 If the defective extension cord is a MSFC-constructed cord, remove it from service and either discard or repair. If repairing cord, use Underwriters Laboratory (UL)-listed parts.

6.4.3 Verify factory-assembled extension cords (power taps, power strips, and multi-outlet cords) are rated (voltage, amperage, and wattage) and correctly sized for their intended use and used according to manufacturer’s instructions.

6.4.4 All extension cords conductor size shall be as large as the conductors in the appliance cord but in NO CASE LESS THAN 14

American Wire Gauge (AWG), unless used in testing or experiment activities.

6.4.4.1 MSFC-constructed extension cords may be constructed with conductor sizes less than 14 AWG when constructed for testing or experiment activities.

6.4.5 Extension cords shall consist of UL-approved round cord with at least three separate insulated wires and pronged connectors in good condition (no nicks or cuts); one of these conductors is the ground.

6.4.5.1 Do not cut off or defeat the ground connection on a plug.

6.4.6 MSFC-constructed extension cords shall be constructed using UL-approved parts and assembled by a qualified employee.

6.4.6.1 Correct phasing of the cord, hot to hot, neutral to neutral, and ground to ground shall be verified during assembly.

6.4.6.2 Only waterproof boxes are allowed for receptacles.

6.4.7 MSFC-constructed cords and factory-assembled cords shall have outer jackets that are rated for hard or extra hard use per NEC Table 400-4, “Flexible Cords and Cables.” One of the following identifiers will be stamped on the cord outer jacket (G, PPE, S, SC, SE, SJ, SO, or ST). Other letters may follow these in the identification of the outer jacket.

6.4.8 Extension cord length in the office area shall not exceed 15 feet. Extension cord length used in testing or experiment activities may exceed 15 feet, if required.

6.4.9 Factory-assembled power taps, power strips, and computer conditioning strips shall have cords no smaller than 14 AWG, equipped with 15 amp surge protection, a reset switch, and be UL approved.

6.4.10 All extension cords must be plugged directly into mounted electrical receptacles. Extension cords shall not be used in series (more than one extension cord connected together to extend a longer distance).

6.4.11 Extension cords shall not be attached to building surfaces.

Exception: Extension cords may be restrained on fire-treated communication backboards using approved non-metallic fasteners.

6.4.12 Cords should be kept clear of walkways where they can become a tripping hazard or damaged. Protect cords by placing along a perimeter wall or under protective covers (floorTrak or floor cable cover).

6.4.13 Never place extension cords above ceiling tiles or inside walls.

6.4.14 Extension cords used for temporary wiring shall comply with the NEC. Temporary usage includes wiring used for the duration of an emergency, test, experiment, development work, construction, or maintenance activity. (Reference NEC, Article 305, “Temporary Wiring,” for detailed requirements.)

6.4.15 All 120-volt, single-phase, 15 and 20 ampere extension cords used outside and/or in damp or wet locations shall have approved ground-fault circuit interrupts (GFIC) and shall have outlets suitable for damp or wet locations. The GFIC shall be for personnel protection.

6.4.16 All 120 volt, single phase, 15 and 20 ampere extension cords used to power equipment used by personnel during maintenance, repair, or similar activities shall have approved GFIC for personnel protection and comply with NEC, Article 305-6, “Ground-Fault Protection for Personnel.”

6.5 Electrical Appliance Safety:

6.5.1 The preferred method for connecting a heat producing appliance (portable heaters, coffee makers, heat lamps, hot plates, ovens, microwaves, grills, etc.) is to plug directly into a wall receptacle, but if an extension cord is needed, a single-outlet extension cord is the preferred method.

6.5.2 Power strips or power taps may be used if ALL the following requirements are met:

6.5.2.1 Only two coffeemakers may be connected to a power strip. The power strip wattage shall not be exceeded.

6.5.2.2 Power strips or power taps shall not be connected in series (reference section 6.4.10).

6.5.2.3 Only one portable electric heater may be connected to a power strip. The power strip wattage shall not be exceeded.

6.5.2.4 No combinations of coffeemakers and portable electric heaters are allowed to be connected to a power strip.

6.5.3 Automatic timers are acceptable to help users ensure coffeemakers are shut “off” during off-duty hours. Shut-off timers may either be built into the unit or a separate device to which the unit's power supply cord is connected. Automatic timers are to be UL listed.

NOTE: Providing this automatic shut-off feature does not relieve the users of their responsibility for ensuring the coffee maker is shut “off.” **Automatic timers shall not be used to turn coffee makers “ON.”**

6.5.4 All portable electric heaters shall be equipped to deenergize electric power to the unit when it is tilted, turned over, or overheats.

6.5.5 Portable appliance permits, MSFC Form 3798, are required for any heat-producing appliance (portable heaters, coffee makers, heat lamps, ovens, microwaves, hot plates, grills, etc.). (Reference MWI 8715.11, “Fire Safety Program.”)

6.6 Abandoned Wiring:

6.6.1 Wiring no longer needed is removed if possible; if not, termination and/or junction points are identified as “abandoned in place.” This identification can be a stick-on tag, a shoestring tag, or written on the device.

6.6.2 Electrical equipment that is no longer in use will be identified as “not in use.” This does not apply to equipment placed in the off position to be used in the future. This identification can be a stick-on tag, a shoestring tag, or written on the device.

6.7 Electrical Panel and Outlets:

6.7.1 Electrical panels and disconnects shall be labeled in accordance with 29 CFR 1910.303 (f), “Identification of Disconnecting Means and Circuits.”

6.7.2 Electrical wall outlets shall be labeled indicating the source electrical panel number and circuit number.

6.7.3 Electrical panels and disconnects shall be capable of being locked out.

6.8 Transformer Banks or High-Voltage Equipment (500+Volts):

6.8.1 Transformer banks and high-voltage equipment shall be protected by an enclosure to prevent unauthorized access.

6.8.2 An authorized access list of qualified employees shall be maintained by the responsible base maintenance organization.

6.8.3 Safe working access and clearance around high-voltage equipment, electrical panels, switch-gear, transformer banks, etc., shall be provided and maintained to permit ready and safety operation and maintenance of the equipment. Clearance distances shall comply with 29 CFR 1910.303(h), Table S-2, “Minimum Depth of Clear Working Space in Front of Electric Equipment.”

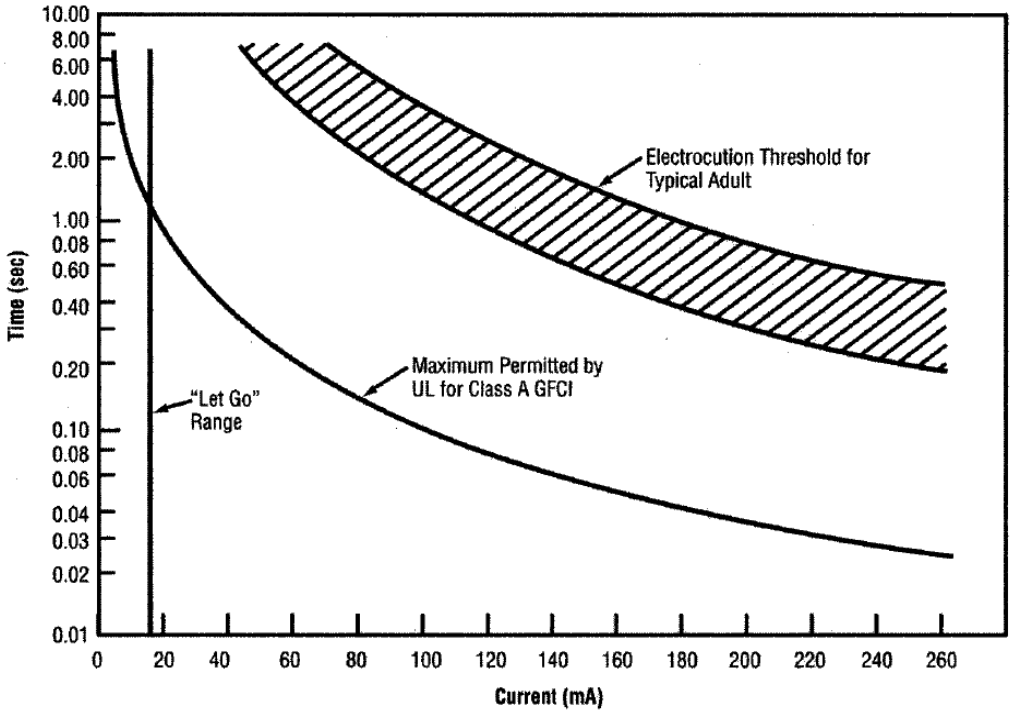
7. NOTES

None

8. SAFETY PRECAUTIONS AND WARNING NOTES

8.1 All exposed electrical terminals, connections, and cables are to be treated as energized or “live parts” by all employees.

8.2 Figure 1, “Effects of Electrical Current and Time on the Human Body”


10.00
8.00
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0.08
0.60
0.40
0.20
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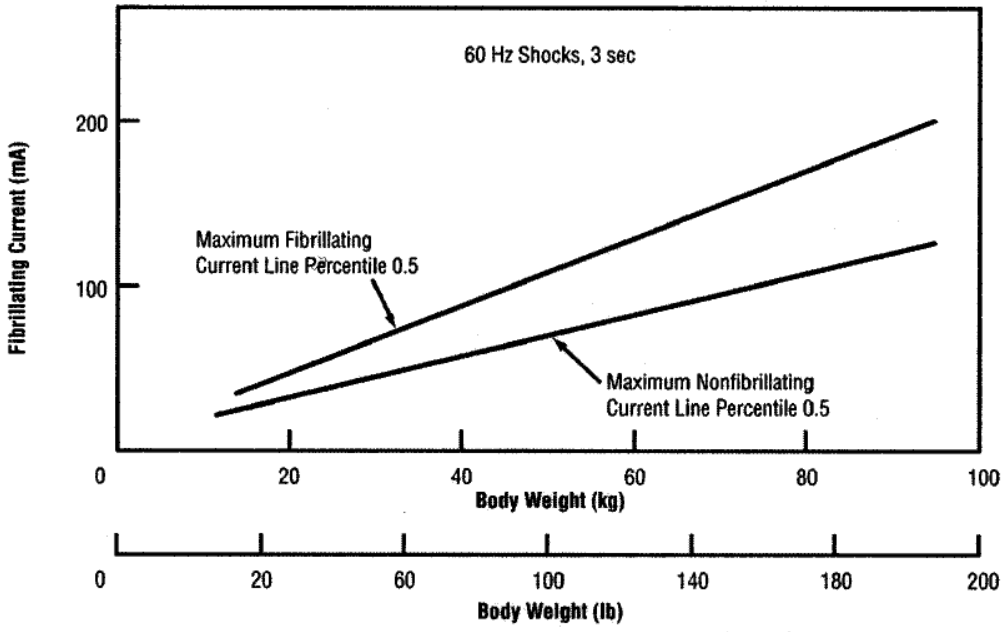
0.08
0.06
0.04
0.03
0.02
0.01
Time (sec)
0
20
40
60
80
100
120
140
160
180
200
220
240
260
Current (mA)
Electrocution Threshold for Typical Adult
Maximum Permitted by UL for Class A GFCI
"Let Go" Range

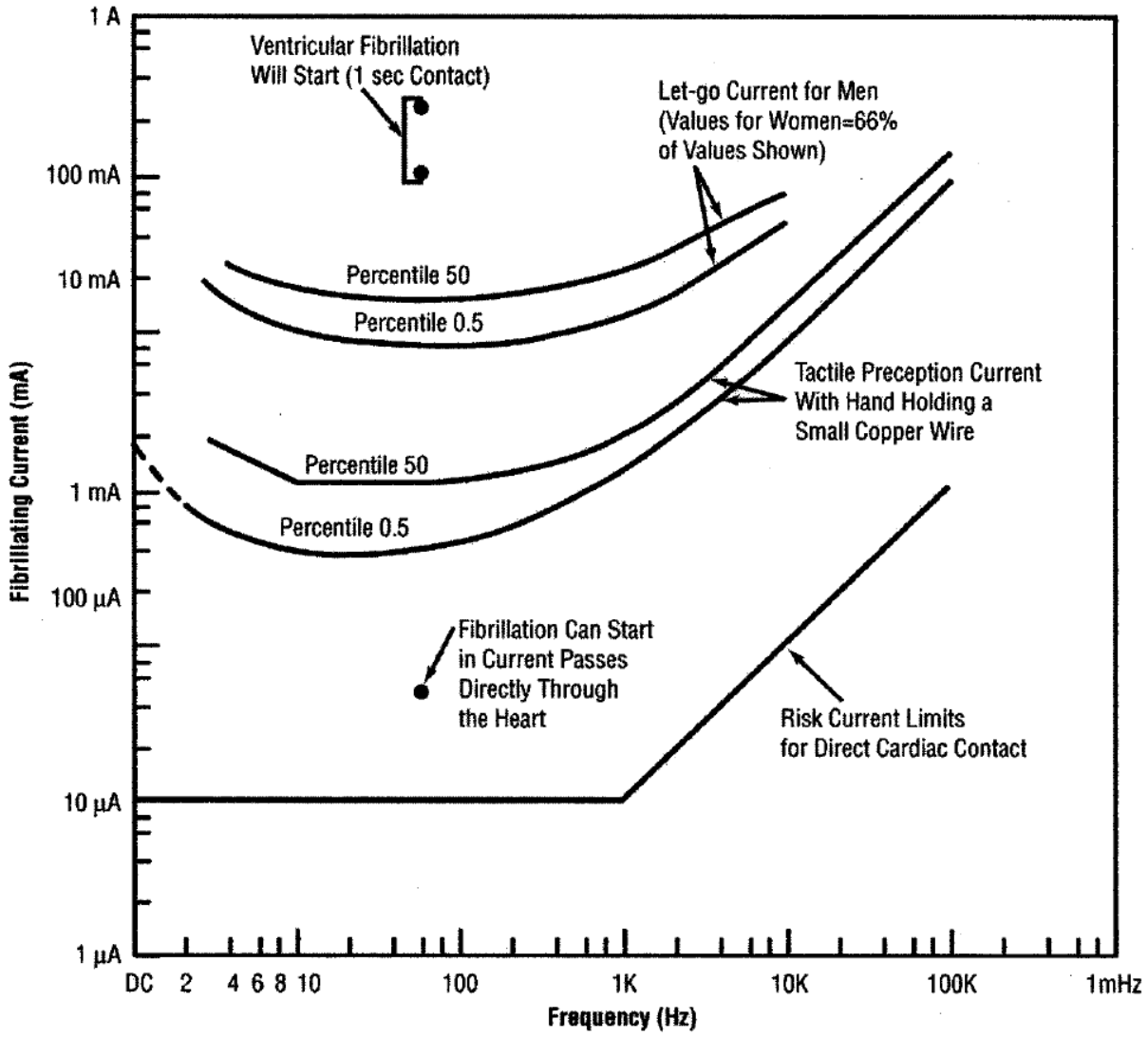
8.3 Figure 2, “Threshold of Sensitivity”

Current Values (mA)		
AC 25–400 Hz	DC	Effects
0–1	0–4	Perception
1–4	4–15	Surprise
4–21	15–80	Reflex Action
21–40	80–160	Muscular Inhibition
40–100	160–300	Respiratory Block
Over 100	Over 300	Usually Fatal

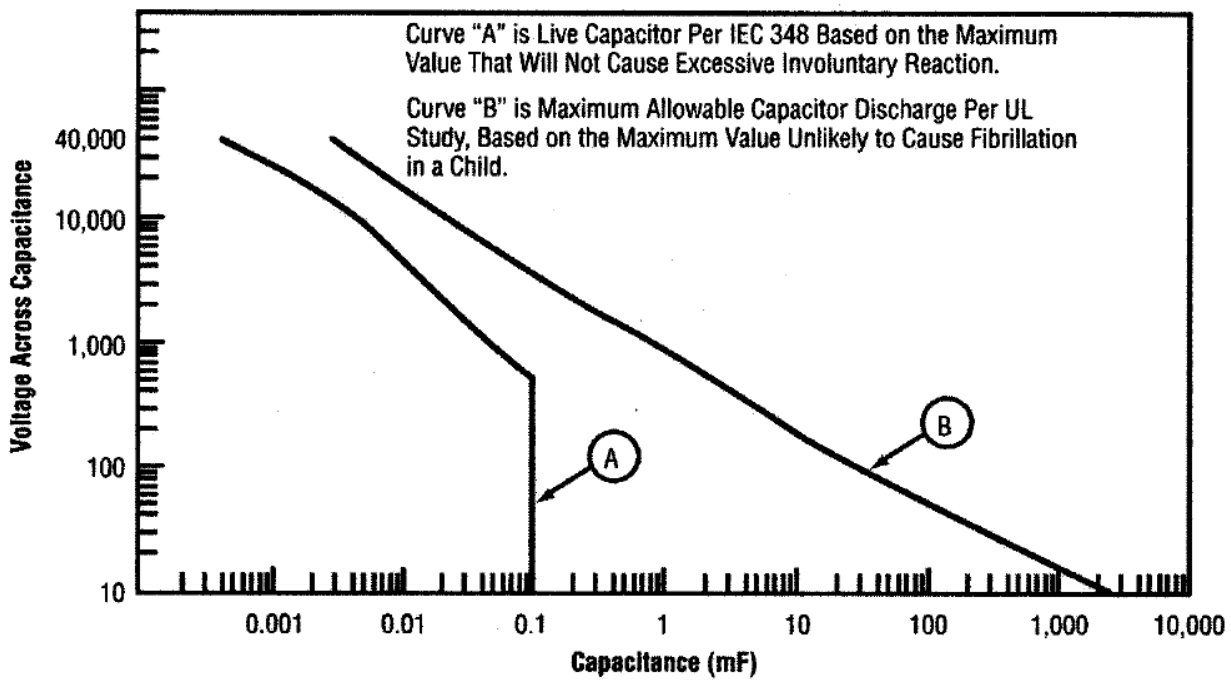
8.4 Figure 3, “Fibrillation Currents vs. Body Weight”



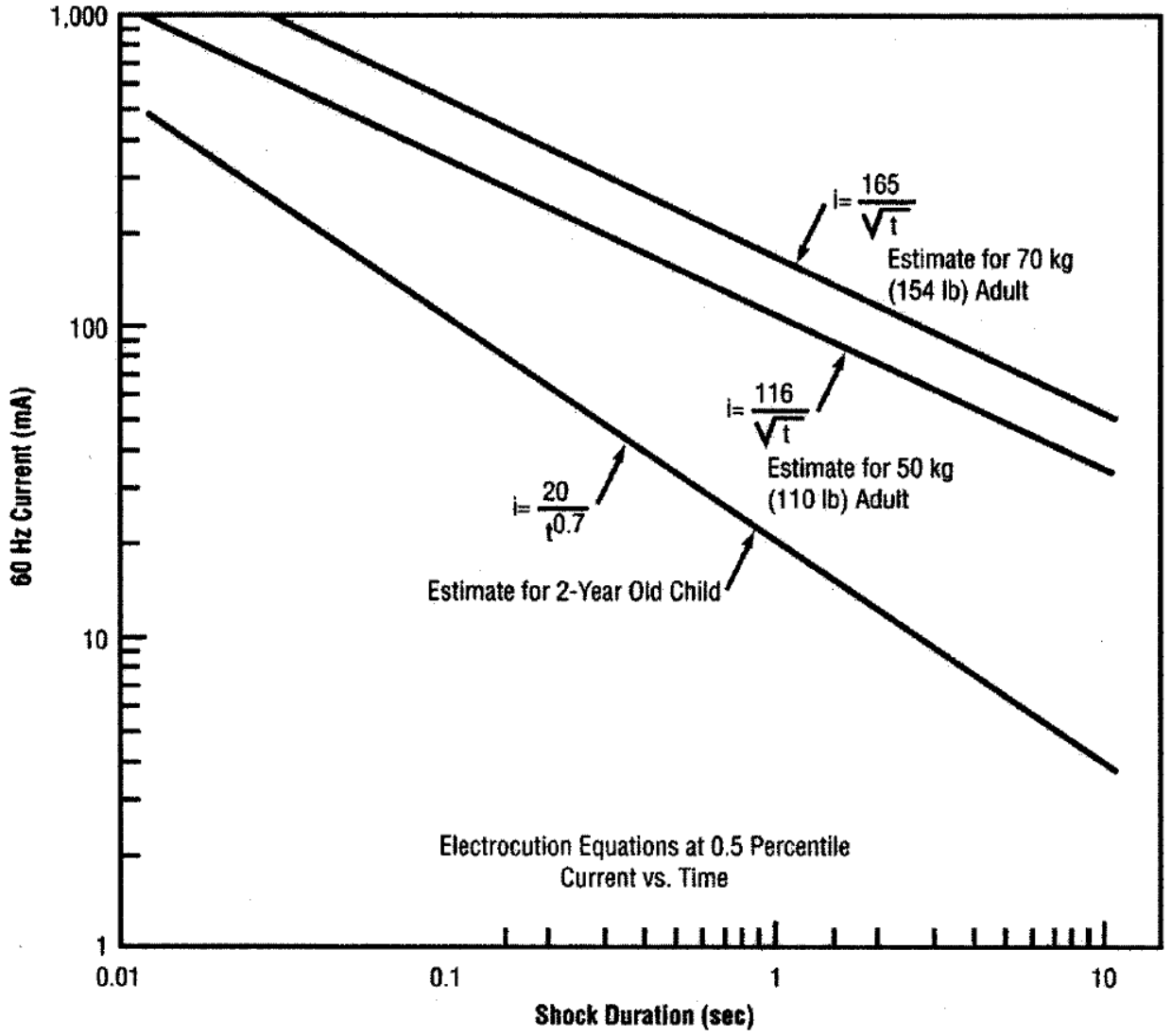
8.5 Figure 4, “Effects on the Body of Electric Current vs. Frequency”



8.6 Figure 5, “Shock Hazard from Capacitor Discharge”



8.7 Figure 6, “Electrocution Equations, Current vs. Time”



8.8 Supervisors shall ensure that no person works alone with high-voltage electricity, or the buddy system is utilized for any job/task deemed as hazardous work in an operating procedure or by a hazardous analysis.

9. RECORDS

9.1 Qualified employee training NSTC 309, “Electrical Safety Standards,” or equivalent shall be forwarded to the Employee and Organizational Development Department (EODD). This record will

be maintained for the length of employment then destroyed or maintained for historical purposes.

9.2 Authorized Employee Lockout/Tagout training NSTC 814, "Lockout/Tagout," or equivalent, as required by 29 CFR 1910.147(c)(7), "The Control of Hazardous Energy (lockout/tagout)," shall be forwarded to EODD. This record will be maintained for the length of employment then destroyed or maintained for historical purposes.

9.2.1 Authorized employees shall forward copies of training to S&MA per MWI 3410.1, "Personnel Certification Program," for inclusion in the CERTRAK data base.

9.3 A qualified employee performing work deemed hazardous, NSTC 0850, "Basic First Aid," or equivalent, and NSTC 0851, "Adult CPR," or equivalent, shall be forwarded to the EODD. This record will be maintained for the length of employment then destroyed or maintained for historical purposes.

10. PERSONNEL TRAINING AND CERTIFICATION

10.1 Supervisors shall ensure any employee that is permitted to work on or near exposed unguarded energized electrical components and equipment with voltages greater than 50 volts to ground are qualified to perform the task. Only a qualified employee is allowed to work with energized electrical equipment where there is a risk of electrical shock.

10.2 Qualified employees, as a minimum, shall be familiar with:

10.2.1 The skills and techniques necessary to distinguish exposed live parts from other parts of electrical equipment.

10.2.2 The skills and techniques necessary to determine the nominal voltage of exposed live parts.

10.2.3 The clearance distances specified in 29 CFR 1910.333(c), "Working On or Near Exposed Energized Parts," and the corresponding voltages to which the qualified employee will be exposed.

10.2.4 This familiarization shall meet the requirements of 29 CFR 1910.332, "Training."

10.3 Typical jobs/tasks at MSFC which require qualified employees training per 29 CFR 1910.333, Table S-4, "Typical

Occupational Categories of Employees Facing a Higher Than Normal Risk of Electrical Accident:"

10.3.1 Blue collar supervisors (1)
10.3.2 Electrical and electronic engineers (1)
10.3.3 Electrical and electronic equipment assemblers (1)
10.3.4 Electrical and electronic technicians (1)
10.3.5 Electricians
10.3.6 Industrial machine operators (1)
10.3.7 Material handling equipment operators (1)
10.3.8 Mechanics and repairers (1)
10.3.9 Painters (1)
10.3.10 Riggers and roustabouts (1)
10.3.11 Welders

Workers in these groups do not need to be trained if their work or the work of those they supervise does not bring them or the employees they supervise close enough to exposed parts of electric circuits operating at 50 volts or more to ground for a hazard to exist.

10.4 Authorized employees working on equipment or systems where energy control procedures are required shall be trained per MWI 8715.2, "Lockout/Tagout," NSTC 814, "Lockout/Tagout," or equivalent.

10.5 Qualified employees that work on electrical equipment and systems deemed hazardous by a hazardous analysis shall be trained in first-aid procedures that include CPR. (Reference NPG 8715.3, "NASA Safety Manual," Chapter 6, "Operational Safety," section 6.8, "Electrical Safety.")

11. FLOW DIAGRAM

None

12. CANCELLATION

MWI 8715.1 dated December 20, 1999

Original Signed by
Sidney P. Saucier for

A. G. Stephenson
Director